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Development of Aerial Releases of *Diachasmimorpha tryoni* (Cameron) (Hymenoptera: Braconidae), a Parasitoid that Attacks the Mediterranean Fruit Fly, *Ceratitis capitata* (Weidemann) (Diptera: Tephritidae), in the Guatemalan Highlands

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A braconid parasitoid, Diachasmimorpha tryoni *(Cameron), was released from the air into Guatemalan coffee plantations that contained Mediterranean fruit flies,* Ceratitis capitata *(Weidemann). Parasitoid adults were chilled, placed in paper bags, and dropped from an altitude of 100 m and at an airspeed of ~ 130 km/h. Releases were made at four different densities over a period of two years. At the higher release rates parasitism levels reached as high as 84%. The feasibility of using a more technically sophisticated aerial release technique, the auger sterile-insect release machine utilized in* C. capitata *sterile-fly aerial eradication projects in California and Florida, was also examined. Chilled* D. tryoni *either alone or in combination with chilled, sterile* C. capitata*, were dropped over target areas and the released parasitoids examined for mortality and damage. Samples of released parasitoids were taken and tested for 'flight ability'; i.e. flight response after an opportunity to recover from chilling. There was no evidence of significant mortality due to aerial release, and the flight-ability of insects released at various rates and altitudes did not significantly differ from chilled controls that were not released from an airplane.*

Keywords: *biological control, augmentative biological control, fruit fly, mass rearing*

INTRODUCTION

The Mediterranean fruit fly (Medfly), *Ceratitis capitata* (Weidemann) infests more than 350 species of fruits and vegetables (Liquido *et al.*, 1990), and is a barrier to trade and a hindrance

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to agricultural development across the tropics and subtropics (Aluja, 1996; Anon., 1993). A number of braconid, chalcidoid, eucoilid, and diapriid parasitoids have been found to attack *C. capitata* (Gilstrap & Hart, 1987), and those introduced into Hawaii have reduced the numbers of *C. capitata* that were present in some areas by 50% (Clausen *et al.*, 1965).

Among the parasitoids released in Hawaii was the opiine braconid *Diachasmimorpha tryoni* (Cameron), a larval-pupal parasitoid originally from Australia where it attacks species of *Bactrocera* (Wharton & Gilstrap, 1983). Augmentative releases of *D. tryoni*, can suppress *C. capitata* populations (Wong *et al.*, 1991), and the combination of augmented parasitoids and sterile males results in greater reductions than either technique employed alone (Wong *et al.*, 1992). In addition, augmentative releases of a related parasitoid, *Diachasmimorpha longicaudata* (Ashmead), lowered adult and larval numbers of the Caribbean fruit fly, *Anastrepha suspensa* (Loew) in Florida (Sivinski *et al.*, 1996). However, releases of *D. longicaudata* against the Oriental fruit fly, *Bactrocera dorsalis* (Hendel), gave inconsistent results with lower populations in the release plots one year and higher populations the next (Purcell, 1998; Purcell *et al.*, 1998).

Large populations of *C. capitata* in Central America continually threaten to invade Mexico and ultimately the USA. For 20 years, the international organization MOSCAMED (medfly in Spanish), representing the USA, Mexico and Guatemala, has been responsible for the maintenance of a barrier to the northward spread of *C. capitata* along the Guatemalan/Mexican border. Malathion bait sprays and sterile male releases have been the principal means of population suppression in the barrier area.

Although there are a number of native fruit fly parasitoids in Guatemala and at least one exotic parasitoid [*Diachasmimorpha longicaudata* (Ashmead)] has been established (Wharton *et al.*, 1981), parasitism of *C. capitata* remains low and sporadic (Eskafi, 1990). It is possible that augmented releases of natural enemies would inflict greater mortality than does naturally occurring parasitism (see Sivinski, 1996), and that this increased mortality would enhance the effectiveness of the sterile male releases along the MOSCAMED barrier.

Previous small scale releases suggested that *D. tryoni* could attack *C. capitata* in the region along the Mexican/Guatemalan border where the releases were to be made (J.S., unpublished data). However, the mountainous terrain of the area precluded the widespread application of parasitoids by spot releases from the ground, the means of release used in prior studies by Wong *et al.* (1992), Sivinski *et al.* (1996), and others (Purcell, 1998; and see previous aerial releases of homopteran parasitoids in Bird, 1987; and Herren *et al.*, 1987).

In order to develop an alternative form of release better suited to the terrain, two forms of aerial release of *D. tryoni* were tested. The first used chilled parasitoids in paper bags which were manually torn open as they exited the aircraft (see Vilasenor Cortes, 1985). Parasitoids were released into areas that were simultaneously treated with sterile insects. A second form of release employed an automated auger system originally designed to dispense chilled sterile flies. In this instance, there was no release made against a target pest population. Rather, we tested whether parasitoids passed through the auger retained their ability to fly or suffered any additional mortality over what was experienced by chilled flies left on the ground.

The various releases and experiments considered together were meant to determine if: (1) aerially released parasitoids delivered by the 'paper bag' method would attack *C. capitata* in the field; (2) whether parasitoid density affects parasitism and what might be the optimal release rate; and (3) whether the technically more sophisticated auger method was a potential alternative to the paper bag method (see Anon, 1995).

METHODS

Field Releases

All of the study sites were in southwestern Guatemala, Department of Quetzaltenango, north of the city of Retalhuleu near the towns of Coatepeque and Colomba (~ longitude 91°45′W,

latitude 14°45′N). The region is mountainous, contains active volcanos, and is extensively planted with coffee (*Coffea arabica* L.). There are intermittent patches of native vegetation, particularly along streams and extremely steep hillsides. At the elevations sampled, coffee was the dominant *C. capitata* host. In the first year, high densities of parasitoids were released at a single site in order to provide the greatest opportunity for parasitoids to attack *C. capitata*. Following the success of this demonstration it was decided that further releases at lower, more economically feasible, rates were justified. In the second year, parasitoids were released at three lower rates in two sites per rate. In order to avoid placing parasitoids in an area previously treated and which might contain the descendants of mass released insects, the locations of the second year of field releases differed from that of the first.

First Year Study Site. *Ceratitis capitata* larvae in two 5 km × 5 km plots were sampled over time (see below). During the experimental period sterile *C. capitata* of both sexes were released over both plots by the standard 'paper bag method' and at the standard rate of 4000/ha/week. In one plot parasitoids were also released (see below).

Three 1 km long transects were sampled in each of the plots. The transects were located roughly at the center of the plot, a margin of the plot, and intermediate between the center and the margin of the plot. In the no parasitoid-control plot, the center transect was located in Finca La Suiza (91°47′W, 14°26′N), the intermediate transect in Finca Santa Anita (91°48′W, 14°25′N) and the margin transect in Finca Colon (91°47′W, 14°26′N). In the parasitoid-release plot, the center transect was located in Finca El Eden (91°37′W, 14°29′N), the intermediate transect in Finca Transito Bolivar (91°38′W, 14°27′N) and the margin transect in Finca San Francisco (91°38′W, 14°28′N). Although altitudes within plots varied by several hundred meters all transects were *ca* 1100 m in altitude and ran through similarly dense plantings of coffee.

Second Year Study Sites. In the second series of releases there was a total of eight 1-km square blocks. The plots receiving parasitoids were concentrated in two larger blocks, i.e. in each block there were four plots, one received no parasitoids and the others different densities of parasitoids. The blocks were centered in the vicinities of El Asintal and Palajunoj (see coordinates below). The altitudes of the plots, 700–800 m, were lower than the sites of the first release series. Those that received no parasitoids were located at 14°39′36″N, 91°44′14″W; and 14°39′36″N, 91°37′00″W. Those that received ~ 286 parasitoids/ha on a weekly basis were located at 14°40′41″N, 91°44′08″W; and 14°40′41″N, 91°37′00″W. Those receiving ~ 567 parasitoids/ha/week were located at 14°40′41″N, 91°44′14″W; and 14°38′31″N, 91°37′00″W. Those receiving ~ 846 parasitoids/ha/week were located at 14°39′36″N, 91°43′08″W; and 14°39′36″N, 91°38′07″W.

Estimation of Coffee Fruit Density. Since *C. capitata* larvae might have been present in different numbers in the various plots we wished to express the densities of released parasitoids in terms of numbers of *D. tryoni* per number of *C. capitata*. In order to estimate the numbers of hosts in each release or control site, it was necessary to determine both the numbers of fruits and the infestation rates of the fruits. In the first series of releases, an observer counted the ripe, red coffee fruits visible to him on paths that paralleled the sampling transects once a week. If no fruits were seen over the 1-km long transect, the observer continued in increments of 200 m until a fruit was found. Coffee density was characterized as fruits/m. This sampling system was initiated during week 13.

Timed collections were used in the second series of releases. Survey personnel picked 100 coffee fruits from the centers of the control or treatment areas and noted the time it took to accomplish the collection. The collection period was not to exceed 30 min.

Estimation of Infestation. Coffee fruits were collected from each transect weekly (see above). Typically amounts ranged from 0.1 to 2 kg, depending on fruit abundance. On the

day of collection the fruits were dissected in the MOSCAMED facility in Coatepeque and all *C. capitata* larvae removed. Their developmental stages were noted and they were placed in containers with clean sand and allowed to pupate under ambient conditions. After one month, emerging adult flies and parasitoids were identified. Since diapause is possible in some fruit fly parasitoids (Aluja *et al.*, 1998), the fate of unemerged pupae was determined by holding these individuals for an additional 11 months. Infestation was calculated as larvae/kg of fruit.

Estimation of Parasitism. Parasitism was calculated as the number of adult parasitoids emerged from a particular sample/the numbers of parasitoids + adult *C. capitata* emerged from the sample. Parasitism of fruit fly larvae by *D. tryoni* in sampled fruits is always underestimated because larvae in picked fruits are inevitably prematurely removed from exposure to the parasitoid. The more complete the development of the sampled larvae the closer their rate of parasitism will resemble that occurring in the field (Purcell *et al.*, 1994). The method of collecting *C. capitata* larvae only allowed successful pupation in nearly mature larvae and minimized underestimates of parasitism (see Wong *et al.*, 1992).

Parasitoid Rearing. *Diachasmimorpha tryoni* were reared on third instar *C. capitata* larvae in a manner similar to those described by Wong and Ramadan (1992) and Sivinski *et al.* (1996). Larvae were irradiated (14.5 kR) prior to parasitism in order to prevent the contamination of parasitoid lots with fertile flies (see Sivinski & Smittle, 1990). Larvae were obtained from a colony established in 1984 at the MOSCAMED facility in San Miguel Petapa and irradiated on site.

Parasitoid Shipment and Adult Emergence. Parasitoid pupae were held in anoxia in 3 l plastic bags and transported in a cooled vehicle at 18–20°C to the MOSCAMED facility in Retalhuleu. There the pupae were placed in lots of 2 l in plastic and screen cages (Consolidated Plastic Co. Inc., Twinsburg, OH) and held with honey and agar at *ca* 24–26°C and 60–70% relative humidity (RH) with a photoperiod of 12 L : 12 D. They were examined daily for adult emergence. Seven days after the first adults were observed and the majority of eclosions had occurred, the cages were placed in a refrigerated room at 3.6°C for 1–1.5 h. Immobile adults were transferred in lots of 20–60 ml, depending on the numbers available, into 200 40 cm × 20 cm × 15 cm paper bags. In order to determine the effect of shipping procedures, adult emergence was measured at both the rearing and pupal holding facilities. This was done by removing pupae from shipping bags and noting the number and sex of the parasitoids emerged by the day of release (see Burns, 1993).

Parasitoid Release. Paper bags containing chilled adults were dropped from a single engine airplane at a height of *ca* 100 m. Air speeds varied between *ca* 130–140 km/h. Drops occurred in the early morning when the winds were relatively still. The bags were torn at the top, released at a rate of 25 bags/min and spaced to land at intervals of 200 m, with the drop pattern alternating weekly between two sets of parallel lines. Since there were two release flights/week, parasitoids were dropped at intervals of 100 m over the period of a week. The first series of releases occurred in the center 4 sq. km of the plot. Comparison of parasitism along the central and marginal transects allowed the movement of adult parasitoids to be estimated. Due to fluctuations in production the release rates varied from 1000–8000 adults/ha/week. The release period preceded and continued through the peak *C. capitata* season; i.e. March–May, a period during the final portion of the dry season (MOSCAMED, unpublished data). Examination in the field of recently dropped bags found the insects to be mobile and engaging in sexual behavior on nearby surfaces. There was no obvious mortality from handling and dropping (see below). In the second year of field releases, each plot received 24 paper bags with ~ equal numbers of parasitoids, the numbers varying with the different release rates. The bags were dropped over three lines, the lines being ~ 300 m apart.

Release Using the Auger Machine Method

Parasitoid *C. capitata* pupae were held in anoxia for *ca* 3 h during transportation to the Guatemalan MOSCAMED Rearing Facility where they were portioned into eclosion containers (see above). Honey and water were provided for emerging adult parasitoids. Seven days later, during which the insects were held under the conditions described above, the eclosion containers were placed in a refrigerated walk-in cooler to immobilize the parasitoids prior to loading into the 'Auger Sterile Release Machine' which had itself been cooled to 2.2–3.9ºC (USDA-APHIS-PPQ-METHODS, Aircraft and Equipment Operations, Mission, Texas, 1995; Parts and Specifications Manual: Auger Sterile Release Machine and Stackable Chill Boxes). The release machine moves a flow of chilled insects from a holding box inside the airplane by means of a turning screw (auger), and the parasitoids exit the airplane through a funnel in the floor.

Releases were made at altitudes ranging from 27–42 m, depending upon weather conditions. Airplane (a twin engine 'Barron' manufactured by Beechcraft, Wichita, KA, USA) speed ranged between 215–235 km/h. Auger potentiometer settings determined the rotation speed of the auger (calculated as [2500 rpm × the potentiometer setting]/airspeed). Potentiometer settings varied from 0.25–0.40 of the maximum with one exception, when the potentiometer was set to 0.99 to clear the machine on a final pass. Because of differences in availability, the volume of parasitoids released per replicate varied from 3.0 to 7.5 l. Parasitoids were released as early in the day as possible, approximately 0600 h, to limit exposure of the parasitoids to high temperatures, wind, and tropical rains.

An initial release was made over a little used dirt/gravel road near Caballo Blanco (Retalhuleu Department). Subsequently, an expanse of concrete at an abandoned seaport facility in Champerico (Retalhuleu Department) was used as the parasitoid release site. The first release was conducted over a distance of *ca* 250 m and the resulting band of dispensed parasitoids was ~ 50 m in width. At the time of release, eight technicians were spaced linearly along the road at intervals of 25 m. Two passes were made over the road with two additional releases made west of the road to compensate for parasitoid drift. The latter passes were over pasture irregularly lined with hedge rows. In subsequent releases, technicians were positioned on the concrete expanse where they aspirated released parasitoids for subsequent quality control examination. They also recorded damaged, dead, or otherwise immobile insects on the ground.

Both before and after aerial releases, samples of parasitoids expelled from the chilled auger machine were obtained for subsequent quality control testing. The aircraft was placed in its hanger, with its engines running and the potentiometer set to 30%. The insects were collected in bags as they left the machine.

Parasitoids taken from the chill room, from the auger machine prior to release, from the ground following aerial release, and from the auger machine following release were aspirated into cups and taken to the laboratory in an insulated box for a quality control test of their 'flight ability'. The flight ability apparatus consisted of a 10-cm high Plexiglas tube, painted black and placed with its base in a 9-cm diameter Petri dish (Brazzel *et al.*, 1986). The inside was lightly coated with talcum powder to prevent the insects from walking out. It was then held under conditions of 25ºC and ~ 60% RH. The number of insects able to exit the container over a period of 24 h of constant indoor-fluorescent light illumination was used to calculate the % flight ability (i.e. the percentage that flew out). Five samples of 100 insects from each of the above conditions were tested for flight ability following each of the 10 aerial release replicates.

RESULTS

Release in Paper Bags—Year 1

The first year's releases were designed to demonstrate the possibility of using aerially released

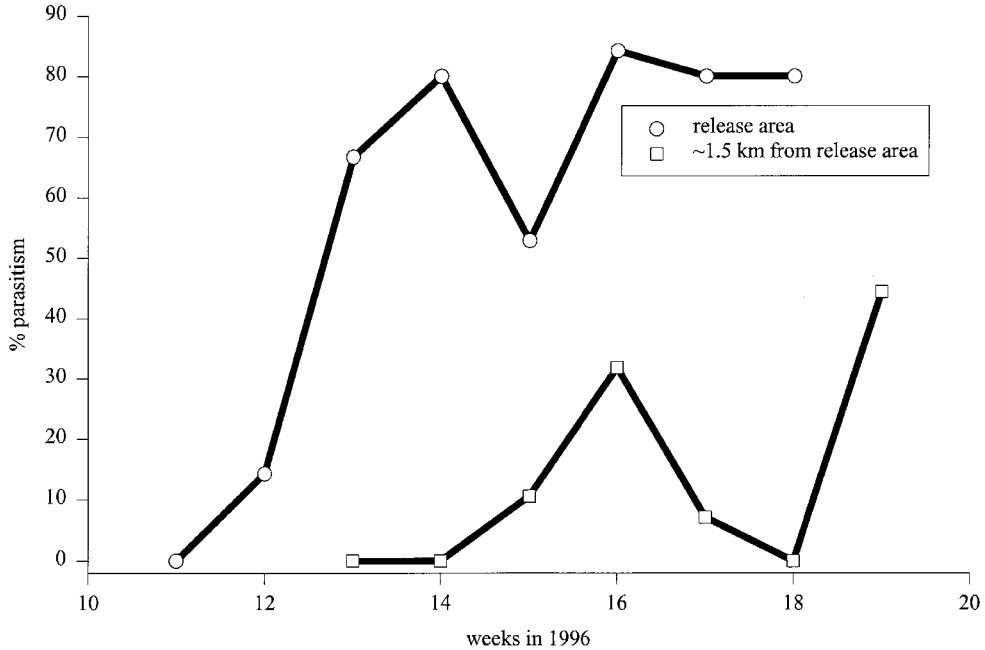

FIGURE 1 Rates of parasitism over time in the center and along the margin of the sterile fly and parasitoid plot. The plot center is the location of the parasitoid releases. The *x*-axis refers to weeks of the year. Parasitoid releases occurred weekly, prior to and during the period examined.

D. tryoni to attack *C. capitata* populations. Parasitoids were released in greater numbers than would be practical in an economically feasible control program.

There had been no previous releases of *D. tryoni* in the plots and nearby fruit collections yielded no evidence of endemic parasitism in the region (MOSCAMED, unpublished data). No parasitoids were recovered in the control plots, and it is likely that all parasitism in the *D. tryoni* release area was due to augmentation. During the peak period of *C. capitata* abundance (weeks 11–18) parasitism along the core transect where aerial drops occurred ranged from 15–84% (Figure 1). *D. tryoni* dispersed from the release area as evidenced by parasitism along the margin of the parasitoid plot at distance of *ca* 1.5 km from the aerial drops (Figure 1).

Release in Paper Bags—Year 2

The second series of releases was designed to help determine practical *D. tryoni* release rates and used lower numbers than the first year's. Second year release rates overlapped those employed by Wong *et al.* (1991) in ground releases in Hawaii (~ 200 ha/week). Different numbers of parasitoids were released in various plots within two separate blocks and the weekly parasitism rates in each were compared in a search for a relationship between release rate and parasitism.

Among the plots (0, 286, 567, and 846 parasitoids/ha/week) in the Palajunoj block there was no relationship between relative parasitoid density (log [parasitoids/number of pupae collected during timed sample]) and determined per cent parasitism ($y = 0.993 + -0.092x$, $r^2 = 0.003$, $F = 0.18$, $p > 0.67$; Figure 2). In the El Asintal block there was a significant positive relationship ($y = -0.558 + 2.403x$, $r^2 = 0.25$, $F = 19.23$, $p < 0.0001$; Figure 2).

In order to obtain the most complete estimates of parasitism as a result of release rate, and so guide any future attempts to control *C. capitata* with augmented *D. tryoni* releases,

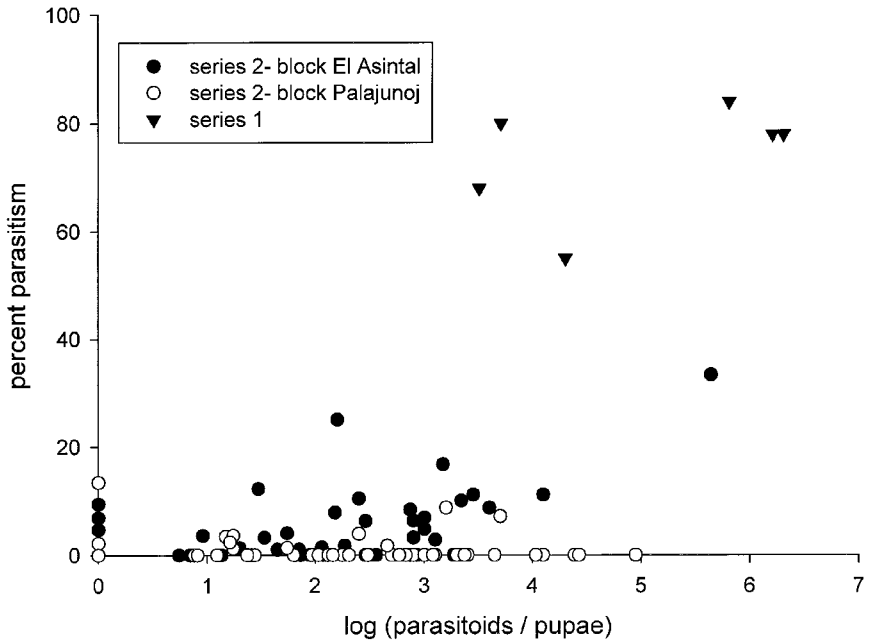

FIGURE 2 The relationship between parasitism of *C. capitata* by *D. tryoni* and the relative rate at which parasitoids are released. The release rate is calculated as the log of the number of parasitoids released/an estimate of host density, i.e. the numbers of mature host larvae collected in timed samples. Each data point represents a weekly value from one of three sites (see text).

the data from the first year's releases, with their higher release rates, were combined with data from the second year (Figure 2). Since host density was measured in two different manners in the two series those from the first series were modified to be compatible with data from the second. This was done by assuming that the spatial samples of the first series (coffee fruits/m) took a similar amount of time to collect as the temporal samples of the second series (coffee fruits/min), and that the resulting numbers of fly larvae obtained from the fruits from both can be roughly compared. With the addition of these estimated data from the first series of releases to the second series from both blocks there is a significant overall relationship between release rate and parasitism ($y = -5.04 + 5.35x$, $r^2 = 0.25$, $F = 41.3$, $p < 0.0001$).

Release from Auger Sterile Release Machine

The quality (flight ability) of *D. tryoni* that had passed through the Auger Sterile Release Machine was compared to that of parasitoids that had not been so treated. This was done to determine if the technologically more sophisticated auger machine was a suitable substitute for the paper bag-release method (see Holler *et al.*, 1996).

The percentages of parasitoids that were damaged or dead following chilling, expulsion from the auger on the ground prior to take off, releases in the air, and expulsion from the auger on the ground following landing are listed in Table 1. Also, calculated are the per cent flight abilities of the insects collected under the above conditions (Table 1). Less than 2.5% of *D. tryoni* in the flight ability tests were non-fliers (<1% if Replicate 2 is eliminated) and 0.5% or less of the parasitoids were damaged. There were no significant increases in mortality or decreases in flight ability as the release procedure moved from the chilling room to the auger machine and onto the ground following release in the air.

TABLE 1. The numbers of *D. tryoni* that flew from a 'flight ability' device, that did not fly, that were damaged, or were dead following chilling alone (CR), chilling and ejection from the auger-release machine prior to flight in an aircraft (PR), chilling, release and ejection from an aircraft (FR), and chilling and ejection from an auger-release machine after the aircraft landed (PO). Means sharing a letter are not significantly different (ANOVA)

		No. of fliers				No. of non-fliers				Damaged insects				Dead insects			
Rep.	No.	CR	PR	FR	PO	CR	PR	FR	PO	CR	PR	FR	PO	CR	PR	FR	PO
1[a]	500[b]	87.8	62.4	93.4	77.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	37.6	6.6	22.5
2[a]	500[c]	76.8	87.8	87.6	81.6	22.8	12.0	12.4	18.2	0.4	0.2	0.0	0.2	0.0	0.0	0.0	0.0
3	500	90.2	95.6	94.6	89.8	0.2	0.0	0.6	0.2	0.6	0.0	0.8	1.0	9.0	4.4	4.0	9.0
4	500[d]	87.4	89.2	85.0	91.1	0.0	0.0	2.4	0.0	0.0	0.0	1.4	0.0	12.6	10.8	11.2	8.9
5	500[e]	86.2	91.6	96.0	89.8	0.2	0.0	0.0	0.0	0.0	0.0	0.8	0.0	13.6	8.4	3.2	10.3
6	500	88.2	89.8	88.0	87.4	0.2	0.0	0.2	0.0	1.2	0.2	0.6	1.2	10.4	10.0	11.2	11.4
7	500	87.6	91.0	94.0	82.4	0.4	0.4	0.6	0.6	0.4	0.2	0.2	0.2	11.6	8.4	5.2	16.8
8	500	89.4	94.2	81.4	79.6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	10.6	5.6	18.6	20.4
9	500	91.2	78.0	82.4	72.6	0.0	0.0	0.0	0.0	0.6	0.2	0.8	0.2	8.2	21.8	16.8	27.2
10	500[f]	92.0	79.2	89.0	56.7	0.2	1.2	0.4	0.0	0.4	1.4	0.2	0.0	7.4	18.2	10.4	27.3
Mean		87.7[a]	85.9[a]	89.1[a]	80.8[a]	2.4[a]	1.4[a]	1.7[a]	1.9[a]	0.4[a]	0.2[a]	0.5[a]	0.3[a]	9.6[a]	12.5[a]	8.7[a]	15.4[a]

[a] Parasitoids were aerially released two days later than scheduled.
[b] 243 parasitoids were collected for the post-release sample.
[c] 250 parasitoids were collected for the field release sample.
[d] 98 parasitoids were collected for the post-release sample.
[e] 300 parasitoids were collected for the post-release sample.
[f] 255 parasitoids were collected for the post-release sample.

DISCUSSION

D. tryoni can be distributed by air. Parasitism of *C. capitata* was sometimes comparable to that found by Wong *et al.* (1992) after ground releases of *D. tryoni* in Hawaii. However, substantial levels of parasitism were only achieved at the highest release rates, and release rates similar to those of Wong *et al.* (1992) (~ 200/ha) had less effect. In one block of release plots there was no significant relationship between the numbers of parasitoids released and the percentage of *C. capitata* parasitized.

The relative ineffectiveness of the Guatemala releases could be the result of several factors. One is that the handling of adults, particularly cooling and dropping from an airplane, damages the insects and renders them incapable of foraging. However, observations of rapid dispersal and immediate sexual signaling by individuals escaping paper bags, and the high values of 'flight ability' of parasitoids exiting the auger, suggest that cooled and aerially released adults are vigorous.

Another reason might be confusion over the actual release rates in the Hawaiian experiments. Wong *et al.* (1992) released parasitoids near various species of infested fruits. Since there were substantial areas of empty pasture between fruit trees the numbers of parasitoids released/area in the Hawaiian and Guatemalan experiments may not be easily compared. That is, the actual area treated within a hectare in the Hawaiian study would typically have been less than a full hectare. This was not the case in Guatemalan releases, where relatively large numbers of bags were dropped into a relatively homogeneous environment.

Alternatively, the lower parasitism rates may be due to differences in the population structure of *C. capitata* in Hawaii and Guatemala rather than differences in release techniques or misinterpretation of releases rates. Paradoxically, the highest populations of adult *C. capitata* in Guatemala occur as the coffee harvest nears completion and infected fruits are relatively rare and scattered (in some plots less than 5 fruits/transect km were collected during particular weeks). Although coffee fruits in any one location are widely dispersed, the enormous area planted in coffee ensures the development of a substantial number of *C. capitata* when environmental conditions are favorable, such as the end of the dry season/finish of the coffee harvest period. It is during this time that the aerial parasitoid releases were performed. Again, Wong *et al.* (1992) released into patchy, but high density, *C. capitata* populations infesting common mixed fruits.

D. tryoni may not be adapted to forage at the low fruit densities typical of late-dry season Guatemala. Parasitism of the tephritid *Anastrepha suspensa* by the related *D. longicaudata* is strongly density dependent (Sivinski *et al.*, 1996). While the reasons for this dependency are unknown, dispersal from relatively unproductive environments is a possible explanation. This raises the question of whether *D. tryoni* has similar foraging tactics, and if so, if it is the best possible choice for late-harvest season augmented releases in the Guatemalan highlands. A species better able to forage at low host densities might be a superior biological control agent (see Sivinski *et al.*, 1998).

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Initiative.' Work was authorized by Gordon Tween, USDA-APHIS-IS as part of a program to improve Moscamed management. He proposed to establish a formal cooperative relationship with PPQ-Methods/ARS to facilitate better management of current resources, i.e. to conduct field evaluation of the SIT, other biological control activities, rear fruit fly parasites, work on diet improvement and development of dry traps.

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